APPENDIX E REVIEW OF EFFECTS OF AIRCRAFT NOISE, CHAFF, AND FLARES ON BIOLOGICAL RESOURCES

1.0 Introduction

This biological resources appendix addresses the effects of aircraft noise, including sonic booms, on wildlife and domestic animals. This appendix also considers the effects of training chaff and flares on biological resources under the training airspaces used by the F-15C, F-15E, and the proposed use by F-22A.

2.0 Aircraft Noise

The review of the noise effects literature shows that the most documented reaction of animals newly or infrequently exposed to low-altitude aircraft and sonic booms is the "startle effect." Although an observer's interpretation of the startle effect is behavioral (e.g., the animal runs in response to the sound or flinches and remains in place), it does have a physiological basis. The startle effect is a reflex; it is an autonomic reaction to loud, sudden noise (Westman and Walters 1981, Harrington and Veitch 1991). Increased heart rate and muscle flexion are the typical physiological responses.

The literature indicates that the type of noise that can stimulate the startle reflex is highly variable among animal species (Manci *et al.* 1988). In general, studies have indicated that close, loud, and sudden noises that are combined with a visual stimulus produce the most intense reactions. Rotary wing aircraft (helicopters) generally induce the startle effect more frequently than fixed wing aircraft (Gladwin *et al.* 1988, Ward *et al.* 1999). Similarly the "crack-crack" of a nearby sonic boom has a higher potential to startle an animal compared to the thunder-like sound from a distant sonic boom. External physical variables, such as landscape structure and wind, can also lessen the animal's perception of and response to aircraft noise (Ward *et al.* 1999).

Animals can habituate to fixed wing aircraft noise as demonstrated under controlled conditions (e.g., Conomy *et al.* 1998, Krausman *et al.* 1998) and by observations reported by biologists working in parks and wildlife refuges (Gladwin *et al.* 1988). Brown *et al.* (1999) defined habituation as "… an active learning process that permits individuals to discard a response to a recurring stimulus for which constant response is biologically inappropriate without impairment of their ability to respond to other stimuli." However, species can differ in their ability to habituate to aircraft noise, particularly the sporadic noise associated with military aircraft training (e.g., Conomy *et al.* 1998). Furthermore, there are no studies that have investigated the potential for adverse effects to wildlife due to long-term exposure to aircraft noise.

Ungulates

Wild ungulates appear to vary in sensitivity to aircraft noise. Responses reported in the literature varied from no effect and habituation to panic reactions followed by stampeding (Weisenberger *et al.* 1996; see reviews in Manci *et al.* 1988). Aircraft noise has the potential to be most detrimental during periods of stress, especially winter, gestation, and calving (DeForge 1981). Krausman *et al.* (1998) studied the response of wild bighorn sheep (*Ovis canadensis*) in a

790-acre enclosure to frequent F-16 overflight at 395 feet AGL. Heart rate increased above preflight level during 7 percent of the overflights but returned to normal within 120 seconds. No behavioral response by the bighorn sheep was observed during the overflights.

Wild ungulates typically have little to no response to sonic booms. Workman *et al.* (1992) studied the physiological and behavioral responses of pronghorn (*Antilocapra americana*), elk (*Cervus elaphus*), and bighorn sheep to sonic booms. All three species exhibited an increase in heart rate lasting from 30 seconds to 1 ½ minutes in response to their first exposure to a sonic boom. After successive sonic booms, this response decreased greatly, indicating habituation.

A recent study in Alaska documented only mild short-term reactions of caribou (*Rangifer tarandus*) to military overflights in the Yukon Military Operations Areas (MOAs) (Lawler *et al.* 2005). A large portion of the Fortymile Caribou Herd calves underneath the Yukon MOAs. The authors concluded that military overflights did not cause any calf deaths, nor did cow-calf pairs exhibit increased movement in response to the overflights. Because daily movements increase with calf age, the authors controlled for calf age in their analysis. Lawler *et al.* (2005) generally only observed higher-level reactions, such as rising quickly from a bedded position or extended running, when the faster F-15 and F-16s were within 1,000 feet above ground level (AGL). They also noted considerable variation in responses due to speed, slant distance, group size and activity, and even individual variation with groups.

In contrast, a study of the Delta Caribou Herd in interior Alaska found that female caribou with calves exposed to low-altitude overflights moved about 2.5 kilometers more per day than those not exposed (Maier *et al.* 1998). The authors, however, stated that this distance was of low energetic cost. Furthermore, this study did not consider calf age in their analyses (Lawler *et al.* 2005), which may bias results. Harrington and Veitch (1991) expressed concern for survival and health of woodland caribou calves in Labrador, where military training flights are allowed within 100 feet AGL.

Few studies of the effects of low-altitude overflights have been conducted on moose (*Alces alces*) or Dall's sheep (*Ovis dalli*). Andersen *et al.* (1996) observed that moose responded more adversely to human stimuli than mechanical stimuli. Beckstead (2004) reported on a study of the effects of military jet overflights on Dall's sheep under the Yukon 1 and 2 MOAs in Alaska. He could find no difference in population trends, productivity, survival rates, behavior, or habitat use between areas mitigated and not mitigated for low-level military aircraft by the Alaska MOAs Environmental Impact Statement (EIS) (United States Air Force [Air Force] 1995). In the mitigated area, flights are restricted to above 5,000 feet AGL during the lambing season, while the unmitigated area could experience flights as low as 100 feet AGL. Similarly, large-force Major Flying Exercises did not adversely affect Dall's sheep.

Marine Mammals

The effects of noise on marine mammals, such as dolphins and whales, have been relatively well studied. Noise behaves differently underwater than in air, so a brief description of noise characteristics in the ocean environment is necessary.

Water is denser than air; therefore, sound waves travel five times faster in water (about 5,000 feet per second) than air (Stocker 2002). This density also allows sound to travel farther underwater. In addition, there are few obstacles (such as trees, houses, etc.) underwater that block sound. Since sound waves are influenced by density, factors that influence the density of water also affect the travel of sound. Temperature, pressure, and salinity can result in varied water densities. The following discussion is from Air Force (2001).

Propagation of sound from air to water is a complicated topic. For a pressure wave arriving at the air/water interface at angles steeper than 13 degrees, the wave is transmitted into the water and propagates at a shallower angle in the water. The pressure in the water at the interface is double the incident pressure, and falls off according to propagation conditions in the water column.

For energy incident from air on the sea surface at angles less than 13 degrees, there is no transmission of energy as a propagating wave into the water. Instead, there is only an evanescent, or non-propagating, wave whose amplitude decays exponentially with depth in the water. As before, there is a doubling of pressure at the interface, but the impact is limited to a region close to the surface and point of incidence. The wave does not propagate on its own in water, but is "bound" to the pressure field in the air. It thus appears to travel horizontally at the velocity of the aircraft.

Because the plane is moving, subsonic noise from an aircraft can have angles both more and less than the critical 13 degrees. The pressure doubles at the surface, propagates for steep arrivals, and decays with depth for the less steep arrivals. For certain ocean conditions, the propagating energy may travel significant distance with low loss intensity. For this reason, a loitering airplane or helicopter may be more worrisome than a fast-moving or supersonic aircraft.

As for military fixed-wing aircraft traveling at subsonic speeds, noise source levels are generally less than 210 decibels (dB) (re 1 μPa at 1 m). For flights at an altitude of 1,000 feet, the maximum sound pressure level at the sea surface would be no greater than about 155 dB (re 1 μPa), which is well below most harassment thresholds in current use (Air Force 2001).

Because marine mammals rely on sound for communication, navigation, and capturing prey, the effect of noise on marine mammals is of particular concern. Anthropogenic noise in the ocean occurs from a variety of sources, ranging from small boats to icebreakers, to oil drilling and seismic exploration. Most of these noise sources are of greater concern than aircraft, for the reasons discussed above. For example, underwater noise from icebreakers (192 to 205 dB are 1 μPa at 1 m) have the potential to result in temporary hearing damage to beluga whales (*Delphinapterus leucas*) staying within 1 to 4 km of an icebreaker for 20 minutes (Erbe and Farmer 2000). In general, reported behavioral responses of marine mammals to aircraft noise range from no reaction to diving (Air Force 2001, Moore and Clarke 2002).

Perry *et al.* (2002) studied the above-water response of gray seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) to sonic booms. They observed no behavioral responses of gray seals to sonic booms, but harbor seals appeared more vigilant. Similarly, gray seals fitted with heart rate monitors showed no change in heart rate during or after a sonic boom while harbor seals showed a slight increase. Perry *et al.* (2002) concluded that sonic booms did not affect breeding behavior of the seals.

Small Mammals

A few researchers have studied the potential affects of aircraft noise on small mammals. Chesser *et al.* (1975) found that house mice (*Mus musculus*) trapped near an airport runway had larger adrenal glands than those trapped 2 kilometers from the airport. In the lab, naïve mice subjected to simulated aircraft noise also developed larger adrenal glands than a control group.

However, the implications of enlarged adrenals for small mammals with a relatively short life span are undetermined. The burrows of some small mammals may reduce their exposure to aircraft noise. Francine *et al.* (1995) found that kit foxes (*Vulpes macrotis*) with twisting tunnels leading to deeper burrows experienced less noise than kangaroo rats (*Dipodomys merriami*) with shallow burrows. McClenaghan and Bowles (1995) studied the effects of aircraft overflights on small mammals and were unable to distinguish potential long-term effects due to aircraft noise compared to other environmental factors.

Raptors

Most studies have found few negative effects of aircraft noise on raptors. Ellis *et al.* (1991) examined behavioral and reproductive responses of several raptor species to low-level flights. No incidents of reproductive failure were observed and site re-occupancy rates were high (95 percent) the following year. Several researchers found that ground-based activities, such as operating chainsaws or an intruding human, were more disturbing than aircraft (White and Thurow 1985, Grubb and King 1991, Delaney *et al.* 1997). Red-tailed hawks (*Buteo jamaicensis*) and osprey (*Pandion haliaetus*) appeared to readily habituate to regular aircraft overflights (Andersen *et al.* 1989, Trimper *et al.* 1998). Mexican spotted owls (*Strix occidentalis lucida*) did not flush from a nest or perch unless a helicopter was as close as 330 feet (Delaney *et al.* 1997). Nest attendance, time-activity budgets, and provisioning rates of nesting peregrine falcons (*Falco peregrinus*) in Alaska were found not to be significantly affected by jet aircraft overflights (Palmer *et al.* 2003). On the other hand, Andersen *et al.* (1990) observed a shift in home ranges of four raptor species away from new military helicopter activity, which supports other reports that wild species are more sensitive to rotary wing aircraft than fixed-wing aircraft.

The effects of aircraft noise on the bald eagle (*Haliaetus leucocephalus*) have been studied relatively well, compared to most wildlife species. Overall, there have been no reports of reduced reproductive success or physiological risks to bald eagles exposed to aircraft overflights or other types of military noise (Fraser *et al.* 1985, Stalmaster and Kaiser 1997, Brown *et al.* 1999; see review in Buehler 2000). Most researchers have documented that pedestrians and helicopters were more disturbing to bald eagles than fixed-wing aircraft, including military jets (Fraser *et al.* 1985, Grubb and King 1991, Grubb and Bowerman 1997). However, bald eagles can be disturbed by fixed-wing aircraft. Recorded reactions to disturbance ranged from an alert posture to flushing from a nest or perch. Grubb and King (1991) reported that 19 percent of breeding eagles were disturbed when an aircraft was within 625 meters (2,050 feet).

Waterfowl and Other Waterbirds

In their review, Manci *et al.* (1988) noted that aircraft can be particularly disturbing to waterfowl. Conomy *et al.* (1998) suggested, though, that responses were species-specific. They found that black ducks (*Anas rubripes*) were able to habituate to aircraft noise, while wood ducks (*Aix sponsa*) did not. Black ducks exhibited a significant decrease in startle response to actual and simulated jet aircraft noise over a 17-day period, but wood duck response did not decrease uniformly following initial exposure. Some bird species appear to be more sensitive to aircraft noise at different times of the year. Snow geese (*Chen caerulescens*) were more easily disturbed by aircraft prior to fall migration than at the beginning of the nesting season (Belanger and Bedard 1989). On an autumn staging ground in Alaska (i.e., prior to fall migration), 75 percent of brant (*Branta bernicla*) and only 9 percent of Canada geese (*Branta canadensis*) flew in response to aircraft overflights (Ward *et al.* 1999). There tended to be a greater response to aircraft at 1,000 to 2,500 feet AGL than at lower or higher altitudes. In contrast, Kushlan (1979) did not observe any negative effects to wading bird colonies (i.e., rookeries) when fixed-wing aircraft conducted surveys within 200 feet AGL; 90 percent of the observations indicated no reactions from the birds. Nesting California least terns (*Sterna albifrons browni*) did not respond negatively to a nearby missile launch (Henningson, Durham, and Richardson 1981).

Previous research also shows varied responses of waterbirds to sonic booms. Burger (1981) found that herring gulls (*Larus argentatus*) responded intensively to sonic booms and many eggs were broken as adults flushed from nests. One study discussed by Manci *et al.* (1988) described the reproductive failure of a colony of sooty terns (*Sterna fuscata*) on the Dry Tortugas reportedly due to sonic booms. However, based on laboratory and numerical models, Ting *et al.* (2002) concluded that sonic boom overpressures from military operations of existing aircraft are unlikely to damage avian eggs.

Domestic Animals

As with wildlife, the startle reflex is the most commonly documented effect on domestic animals. Results of the startle reflex are typically minor (e.g., increase in heart rate or nervousness) and do not result in injury. Espmark *et al.* (1974) did not observe any adverse effects due to minor behavioral reactions to low-altitude flights with noise levels of 95 to 101 A-weighted decibels (dBA). They noted only minimal reactions of cattle and sheep to sonic booms, such as muscle and tail twitching and walking or running short distances (up to 65 feet). More severe reactions may occur when animals are crowded in small enclosures, where loud, sudden noise may cause a widespread panic reaction (Air Force 1993). Such negative impacts were typically only observed when aircraft were less than 330 feet AGL (United States Forest Service 1992). Several studies have found little direct evidence of decreased milk production, weight loss, or lower reproductive success in response to aircraft noise or sonic booms. For example, Head *et al.* (1993) did not find any reductions in milk yields with aircraft Sound Exposure Levels (SEL) levels of 105 to 112 dBA. Many studies documented that domestic animals habituate to aircraft noise (see reviews in Manci *et al.* 1998; Head *et al.* 1993).

There is little direct evidence that aircraft noise or sonic booms can cause domestic chicken eggs to crack or result in lower hatching rates. Stadelman (1958) did not observe a decrease in hatchability when domestic chicken eggs were exposed to loud noises measured at 96 dB inside incubators and 120 dB outside. Bowles and Seddon (1994) found no difference in the hatch rate of four groups of chicken eggs exposed to 1) no sonic booms (control group), 2) sonic booms of 3 pounds per square foot (psf), 3) sonic booms of 20 psf, and 4) sonic booms of 30 psf. No eggs were cracked by the sonic booms and all chicks hatched were normal.

3.0 Training Chaff and Flares

Specific issues and potential impacts of training chaff and flares on biological resources are discussed below. These issues have been identified by Department of Defense (DoD) research (Air Force 1997, Cook 2001), General Accounting Office review (United States General Accounting Office 1998), independent review (Spargo 1999), resource agency instruction, and public concern and perception. No reports to date have documented negative impacts of training chaff and flares to biological resources. These studies are reviewed below.

Concerns for biological resources are related to the residual materials of training chaff and flares that fall to the ground or dud flares. Residual materials are several flare components, including plastic end caps, felt spacers, aluminum-coated wrapping material, plastic retaining devices, and plastic pistons. Specific issues are (1) ingestion of chaff fibers or flare residual materials; (2) inhalation of chaff fibers; (3) physical external effects from chaff fibers, such as skin irritation; (4) effects on water quality and forage quality; (5) increased fire potential; and (6) potential for being struck by large flare debris (the plastic Safe and Initiation [S&I] device of the MJU-7 A/B flare).

Because of the low rate of application and dispersal of training chaff fibers and flare residues during defensive training, wildlife and domestic animals would have little opportunity to ingest, inhale, or otherwise come in contact with these residual materials. Although some chemical components of chaff are toxic at high levels, such levels could only be reached through the ingestion of many chaff bundles or billions of chaff fibers. Barrett and MacKay (1972) documented that cattle avoided consuming clumps of chaff in their feed. When calves were fed chaff thoroughly mixed with molasses in their feed, no adverse physiological effects were observed pre- or post-mortem.

Chaff fibers are too large for inhalation, although chaff particles can degrade to small pieces. However, the number of degraded or fragmented particles is insufficient to result in disease (Spargo 1999). Chaff is similar in form and softness to very fine human hair, and is unlikely to cause negative reactions if animals were to inadvertently come in contact with it.

Chaff fibers could accumulate on the ground or in water bodies. Studies have shown that chaff breaks down quickly in humid environments and acidic soil conditions (Air Force 1997). In water, only under very high or low pH could the aluminum in chaff become soluble and toxic (Air Force 1997). Few organisms would be present in water bodies with such extreme pH levels. Given the small amount of diffuse or aggregate chaff material that could possibly reach water bodies, water chemistry would not be expected to be affected. Similarly, the magnesium in flares can be toxic at extremely high levels, a situation that could occur only under repeated and concentrated use in localized areas. Flare ash would disperse over wide areas; thus, no impact is expected from the magnesium in flare ash. The probability of an intact dud flare leaving an aircraft during training and falling to the ground outside of a military base is estimated to be 0.01 percent (Air Force 2001). Since toxic levels would require several dud flares to fall in one confined water body, no effect of flares on water quality would be expected. Furthermore, uptake by plants would not be expected to occur.

The expected frequency of an S&I device from an MJU-7 A/B flare striking an exposed animal depends on the number of flares used and the size and population density of the exposed animals. Calculations of potential strikes to a human-sized animal with a density of 50 animals per square mile, where 8,000 flares were used annually, was one strike in 200 years. An animal 1/100th the size of a human with a density of 500 animals per square mile exposed 100 percent of the time (i.e., animals not protected by burrows or dense vegetation) would also have an expected strike rate of one in 200 years. The S&I device strikes with the force of a medium-sized hailstone. Such a strike to a bird, small mammal, or reptile could produce a mortality. The very small likelihood of such a strike, especially when compared with more immediate threats such as highways, would not be expected to have any effect on populations of small species. Strikes to larger species, such as wild ungulates or farm animals could produce a bruise and a startle reaction. Such a strike from an S&I device would not be expected to seriously injure or otherwise significantly affect natural or domestic species.

Flare debris also includes aluminum-coated mylar wrapping and lighter plastic parts. The plastic parts, such as end caps, are inert and are not expected to be used by or consumed by any species. The aluminum coated wrapping, as it degrades, could produce fibrous materials similar to naturally occurring nesting materials. There is no known case of such materials being used in nest construction. In a study of pack rats (*Neotoma* spp.), a notorious collector of odd materials, no chaff or flare materials were found in nests on military ranges subject to decades of dispensing chaff and flares (Air Force 1997). Although lighter flare debris could be used by species under the airspace, such use would be expected to be infrequent and incidental.

Bovine hardware disease is of concern for domestic cattle. Hardware disease, or traumatic reticuloperitonitis, is a relatively common disease in cattle. The disease results when a cow ingests a foreign object, typically metallic. The object can become lodged in the wall of the stomach and can penetrate into the diaphragm and heart, resulting in pain and infection; in severe cases animals can die without treatment. Treatment consists of antibiotics and/or surgery. Statistics are not readily available, but one study documented that 55-75 percent of cattle slaughtered in the eastern United States (U.S.) had metallic objects in their stomachs, but the objects did not result in damage (Moseley 2003). Dairy cattle are typically more vulnerable to hardware disease due to the confined nature of diary operations. Many livestock managers rely on magnets inserted into the cow's stomach to prevent and treat hardware disease. The magnet attracts metallic objects, thereby preventing them from traveling to the stomach wall.

The culprit of bovine hardware disease is often a nail or piece of wire greater than 1 inch in length, such as that used to bale hay (Cavedo et al. 2004). If livestock ingested residual materials of the M-206 and MJU-7 A/B flares, the plastic materials of the end cap and slider and the flexible aluminum wrapping would be less likely to result in injury than a metallic object.

Flares used for training by F-15 and F-22 aircraft are designed to burn out within approximately 400 feet of the release altitude. Given the minimum allowable release altitudes for flares, this leaves an extensive safety margin to prevent any burning materials from reaching the ground (Air Force 2001). In the Alaska training airspace, flares must be released above 5,000 feet AGL from June 1 to September 30 to reduce any potential of a flare-caused fire. For the remainder of the year when soils and vegetation are moist or snow covered, flares can be released above 2,000 feet AGL. Plastic and aluminum coated wrapping materials from flares that do reach the ground would be inert. The percentage of flares that malfunction is small (<1 percent probability for all categories of malfunction; Air Force 2001). Dud flares (i.e., those that do not ignite at release and fall intact to the ground) contain magnesium, which is thermally stable and requires a temperature of 1,200 degrees Fahrenheit for ignition. Self-ignition is highly unlikely under natural conditions.

4.0 References

Andersen, D.E., O.J. Rongstad, and W.R. Mytton. 1989. Response of Nesting Red-tailed Hawks to Helicopter Overflights. Condor 91:296-299.

_____ . 1990. Home-Range Changes in Raptors Exposed to Increased Human Activity Levels in Southeastern Colorado. Wildlife Society Bulletin 18(2):134-142.

Andersen, R., J.D.C. Linnell, and R. Langvatn. 1996. Short Term Behavioral and Physiological Responses of Moose *Alces alces* to Military Disturbance in Norway. Biological Conservation 77:169-176.

Barrett, B.B., and R.R. MacKay. 1972. The Ingestion of Fiberglass Chaff by Cattle. Animal Diseases Research Institute, Canada Department of Agriculture/Health of Animals Branch.

Beckstead, D. 2004. The Effects of Military Jet Overflights on Dall's Sheep in Interior Alaska. Available at http://www.nps.gov/yuch/Expanded/key_resources/sheep/2004_sheep_report/toc.htm. Accessed December 29, 2005.

Belanger, L. and J. Bedard. 1989. Responses of Staging Greater Snow Geese to Human Disturbance. Journal of Wildlife Management 53(3):713-719.

Bowles, A. E., and M. D. Seddon. 1994. Effects of simulated sonic booms on the hatchability of white leghorn chicken eggs. Armstrong Laboratory, Air Force Materiel Command, Brooks Air Force Base, TX. AL/OE-TR-0179.

Brown, B.T., G.S. Mills, C. Powels, W.A. Russell, G.D. Therres, and J.J. Pottie. 1999. The Influence of Weapons-Testing Noise on Bald Eagle Behavior. Journal of Raptor Research 33(3):227-232.

Buehler, D.A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). In The Birds of North America, No. 506 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Burger, J. 1981. Behavioral Responses of Herring Gulls *Larus argentatus* to Aircraft Noise. Environmental Pollution (Series A):177-184.

Cavedo, A. M., K. S. Latimer, H. L. Tarpley, and P. J. Bain. 2004. Traumatic Reticulopertonitis (Hardware Disease) in Cattle. Class of 2004 and Department of Pathology, College of Veterinary Medicine, University of Georgia, Athens, GA. Available at http://www.vet.uga.edu/vpp/clerk/cavedo. Accessed 6/23/2005.

Chesser, R.K., R.S. Caldwell, and M.J. Harvey. 1975. Effects of Noise on Feral Populations of *Mus musculus*. Physiological Zoology 48(4):323-325.

Conomy, J.T., J.A. Dubovsky, J.A. Collazo, and W.J. Fleming. 1998. Do Black Ducks and Wood Ducks Habituate to Aircraft Disturbance? Journal of Wildlife Management 62(3):1135-1142.

Cook, B.C. 2001. Investigation of Abrasion, Fragmentation and Re-suspension of Chaff. Master's Thesis. Christopher Newport University.

DeForge, J.R. 1981. Stress: Changing Environments and the Effects on Desert Bighorn Sheep. Desert Bighorn Council 1981 Transactions.

Delaney, D.K., T.G. Grubb, and L.L. Pater. 1997. Effects of Helicopter Noise on Nesting Mexican Spotted Owls. Project Order No. DE P.O. 95-4, U.S. Air Force, Holloman Air Force Base, New Mexico.

Ellis, D.H., C.H. Ellis, and D.P. Mindell. 1991. Raptor Responses to Low-Level Jet Aircraft and Sonic Booms. Environmental Pollution 74:53-83.

Erbe, C., and D. M. Farmer. 2000. Zones of Impact around Icebreakers Affecting Beluga Whales in the Beaufort Sea. Journal of the Acoustical Society of America 108(3):1332-1340.

Espmark, Y., L. Falt, and B. Falt. 1974. Behavioral Responses in Cattle and Sheep Exposed to Sonic Booms and Low-altitude Subsonic Flight Noise. The Veterinary Record 94:106-113.

Francine, J.K., J.S. Yaeger, and A.E. Bowles. 1995. Sound from Low-Altitude Jet Overflights in Burrows of the Merriam's Kangaroo Rat, *Dipodomys merriami*, and the Kit Fox, *Vulpes macrotis*. *In* R. J. Bernhard and J. S. Bolton. Proceedings of Inter-Noise 95: The 1995 International Congress on Noise Control Engineering. Volume II. Pages 991-994.

Fraser, J.D., L.D. Frenzel, and J.E. Mathisen. 1985. The Impact of Human Activity on Breeding Bald Eagles in North-Central Minnesota. Journal of Wildlife Management 49(3):585-592.

Gladwin, D.N., D.A. Asherin, and K.M. Manci. 1988. Effects of Aircraft Noise and Sonic Booms on Fish and Wildlife. Results of a Survey of U.S. Fish and Wildlife Service Endangered Species and Ecological Services Field Offices, Refuges, Hatcheries, and Research Centers. U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, Colorado.

Grubb, T.G. and R.M. King. 1991. Assessing Human Disturbance of Breeding Bald Eagles with Classification Tree Models. Journal of Wildlife Management 55(3):500-511.

Grubb, T.G. and W.W. Bowerman. 1997. Variations in Breeding Bald Eagle Responses to Jets, Light Planes and Helicopters. Journal of Raptor Research 31(3):213-222.

Harrington, F.H., and A.M. Veitch. 1991. Short-term Impacts of Low-level Jet Fighter Training on Caribou in Labrador. Arctic 44(4):318-327.

Head, H. H., R. C. Kull, Jr., M. S. Campos, K. C. Bachman, C. J. Wilcox, L. L. Cline, and M. J. Hayen. 1993. Milk Yield, Milk Composition, and Behavior of Holstein Cows in Response to Jet Aircraft Noise before Milking. Journal of Dairy Science 76:1558-1567.

Henningson, Durham and Richardson. 1981. Effects of Minuteman Launch on California Least Tern Nesting Activity, Vandenberg AFB, California. Prepared for U.S. Air Force, Ballistic Missile Office, Norton Air Force Base, California.

Krausman, P.R., M.C. Wallace, K.L. Hayes, and D.W. DeYoung. 1998. Effects of Jet Aircraft on Mountain Sheep. Journal of Wildlife Management 62(4):1246-1254.

Kushlan, J. A. 1979. Effects of Helicopter Censuses on Wading Bird Colonies. Journal of Wildlife Management 43(3):756-760.

Lawler, J. P., A. J. Magoun, C. T. Seaton, C. L. Gardner, R. D. Bobertje, J. M. Ver Hoef, and P. A. Del Vecchio. 2005. Short-term Impacts of Military Overflights on Caribou during Calving Season. Journal of Wildlife Management 69(3):1133-1146.

Maier, J. A. K., S. M. Murphy, R. G. White, and M. D. Smith. 1998. Responses of Caribou to Overflights by Low-Altitude Jet Aircraft. Journal of Wildlife Management 62(2):752-766.

Manci, K.M., D.N. Gladwin, R. Villella, and M. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, CO. NERC-88/29.

McClenaghan, L, and A.E. Bowles. 1995. Effects of Low-Altitude Overflights on Populations of Small Mammals on the Barry M. Goldwater Range. *In* R. J. Bernhard and J. S. Bolton.

Proceedings of Inter-Noise 95: The 1995 International Congress on Noise Control Engineering. Volume II. Pages 985-990.

Moore, S. E., and J. T. Clarke. 2002. Potential Impact of Offshore Human Activities on Gray Whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management 4(1):19-25.

Moseley, B. L. 2003. Hardware Disease in Cattle. University of Missouri, MU Extension. Available at http://muextension.missouri.edu/explore/agguides/pests/g07700.htm. Accessed 7/26/2005.

Palmer, A.G., D.L. Nordmeyer, and D.D. Roby. 2003. Effects of Jet Aircraft Overflights on Parental Care of Peregrine Falcons. Wildlife Society Bulletin 31(2):499-509.

Perry, E. A., D. J. Boness, and S. J. Insley. 2002. Effects of Sonic Booms on Breeding Gray Seals and Harbor Seals on Sable Island, Canada. Journal of the Acoustical Society of America 111(1):599-609.

Spargo, B.J. 1999. Environmental Effects of RF Chaff: a Select Panel Report to the Undersecretary of Defense for Environmental Security. NRL/PU/6100—99-389, Washington, D.C.

Stadelman, W.J. 1958. The effect of sounds of varying intensity on hatchability of chicken eggs. Poultry Sciences 37:166-169.

Stalmaster, M.V. and J.L. Kaiser. 1997. Flushing Responses of Wintering Bald Eagles to Military Activity. Journal of Wildlife Management 61(4):1307-1313.

Stocker, M. 2002. Fish, Mollusks and other Sea Animals, and the Impact of Anthropogenic Noise in the Marine Acoustical Environment. Michael Stocker Associates, For Earth Island Institute.

Ting, C., J. Garrelick, and A. Bowles. 2002. An Analysis of the Response of Sooty Tern Eggs to Sonic Boom Overpressures. The Journal of the Acoustical Society of America 111(1):562-568.

Trimper, P.G., N.M. Standen, L.M. Lye, D. Lemon, T.E. Chubbs, and G.W. Humphries. 1998. Effects of Low-level Jet Aircraft Noise on the Behaviour of Nesting Osprey. Journal of Applied Ecology 35:122-130.

United States Air Force (Air Force). 1993. The Impact of Low Altitude Flights on Livestock and Poultry. AF Handbook #-#, Volume 8.

United States Air Force (Air Force). 1997. Environmental Effects of Self Protection Chaff and Flares. Final Report. August.

_____ . 2001. Final Environmental Assessment for the Defensive Training Initiative, Cannon Air Force Base, New Mexico. Prepared for Air Combat Command, Langley Air Force Base, Virginia.

United States Forest Service. 1992. Report to Congress: Potential Impacts of Aircraft Overflights of National Forest System Wilderness. Prepared pursuant to Public Law 100-91, The National Parks Overflights Act of 1987.

United States General Accounting Office. 1998. DoD Management Issues Related to Chaff: Report to the Honorable Harry Reid, U.S. Senate.

Ward, D.H., R.A. Stehn, W.P. Erickson, and D.V. Derksen. 1999. Response of Fall-Staging Brant and Canada Geese to Aircraft Overflights in Southwestern Alaska. Journal of Wildlife Management 63(1):373-381.

Weisenberger, M.E., P.R. Krausman, M.C. Wallace, and D.W. De Young, and O.E. Maughan. 1996. Effects of Simulated Jet Aircraft Noise on Heart Rate and Behavior of Desert Ungulates. Journal of Wildlife Management 60(1):52-61.

Westman, J.C., and J.R. Walters. 1981. Noise and Stress: a Comprehensive Approach. Environmental Health Perspectives 41:291-309.

White, C.M., and T.L. Thurow. 1985. Reproduction of Ferruginous Hawks Exposed to Controlled Disturbance. Condor 87:14-22.

Workman, G.W., T.D. Bunch, L.S. Neilson, E.M. Rawlings, J.W. Call, R.C. Evans, N.R. Lundberg, W.T. Maughan, and J.E. Braithwaite. 1992. Sonic Boom/Animal Disturbance Studies on Pronghorn Antelope, Rocky Mountain Elk, and Bighorn Sheep. Utah State University. Contract number F42650-87-0349. Submitted to U.S. Air Force, Hill Air Force Base, Utah.

THIS PAGE INTENTIONALLY LEFT BLANK.